GLOBAL POSITIONING SYSTEMS IN COMBAT

Global Positioning Systems in Combat

MSG Shouse, SGM Scott, MSG Upchurch, MSG Williams, W01 Chew

United States Army Sergeants Major Academy

Class # 58

SGM Caspari

26 November 2007

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
26 NOV 2007		**00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Global Positioning Systems in Combat	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Sergeants Major Academy,11291 Sgt. E.Churchill St,Fort Bliss,TX,79918**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**27**	

Abstract

This essay speaks of the overall advantages gained by the use of Global Positioning Systems (GPS) in combat. Fratricide has been reduced because of the effective use of GPS in common equipment employed by troops. Collateral damage that might otherwise cause friction and strife in the civilian population has nearly been negated because of GPS accuracy. The effective use of GPS guided missiles and bombs has allowed for much less troop exposure, ultimately resulting in fewer Soldier casualties than previously noted in wars without the use of GPS technology. The future holds even more hope for success for the integration of GPS into future battlefield weapons and equipment. As GPS becomes more and more accurate, its use allows for a clear gain in a battlefield edge. As with many advancing technologies, the opportunity exists for the adversary's exploitation. GPS is susceptible to jamming, but the gains from its use far outweigh the risk taken.

Global Positioning Systems in Combat

Thesis Statement: The advantages of using Global Positioning Systems (GPS) in combat have proven to reduce fratricide, collateral damage, and the number of personnel exposed in harm's way and these proven benefits far outweigh the risk of the GPS signal being exploited by the adversary.

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Global Positioning Systems in Combat

The use of the Global Positioning System (GPS) in combat gives the United States forces a deciding edge on the battlefield against its adversaries. Most recently during Operation Iraqi Freedom (OIF) in 2003, the ability to use GPS enhanced precision-guided missiles to strategically eliminate valuable targets allowed for effective use of follow-on ground troops. The accuracy provided by GPS reduced collateral damage and fratricide, and continues to the present day situation. The future of GPS will allow for even more advantages, continuing to allow U.S. forces to distance themselves against future potential threats.

War Without GPS

There are many unfortunate tragedies caused by fratricide during wars. In both world wars, friendly fires caused numerous casualties and mainly were due to artillery indirect fires and bombers inadvertently bombing on positions held by friendly forces. During the First World War, of the 3.3 million French casualties, 75,000 were caused by artillery fratricide. A study concluded that during the Second World War, of the 774,000 American casualties about 124,000 Soldiers were wounded or killed by friendly forces. In Saint-Lo, France, over 700 casualties occurred when American ground forces were attacked by U.S. bombers. American forces fighting in both Vietnam and Korea also suffered high casualty rates from friendly fires in both theaters. On most occasions the cause of the accident was due to forces on the ground being unable to describe the target accurately to the supporting fire, leading to the supporting fire inaccurately firing onto the correct target, hence creating a huge amount of tragedy in the war. These are the effects of war without GPS (Joint Forces Staff College, 2002).

The earliest version of the GPS was the radio-based navigation system, developed in the 1940s and used in the Second World War. When Russia launched the satellite Sputnik into space

in 1957, a group of U.S. researchers discovered that the satellite signal from Sputnik was able to track ground positions. This discovery led to the future development of GPS. The first satellite navigation system was tested by the U.S. Navy in 1960 using five satellites. In the late 1960s the satellite navigation system had improved and the satellite signal was able to locate the ground position within fifteen minutes. In 1973, the U.S. Department of Defense understood the important of the GPS system and started developing the defense GPS system (Global Positioning System, 2007).

In 1978 the U.S. Military launched the first four GPS satellites into space. From 1978 to 1995, numerous new satellites were launched into space and GPS continued to be developed and reached full operational status in 1995. The U.S. Military also announced the development of two different GPS services for public and military usage. This development denied the full capability of GPS to potential U.S. enemies. From 2001 to 2003, the battles in Afghanistan and during OIF demonstrated the precision of GPS in modern battle (Goetsch, 2005).

GPS in Modern Warfare

GPS can be used in various military weapons systems to track potential sea, ground, and air targets. This enables the weapons systems to positively identify the target and accurately fire on the target. For fighter jets and bombers, GPS accurately finds and identifies the target described by the ground forces. This resulted in lowering the chances of fratricide. In modern warfare, GPS enabled weapons like cruise missiles, intercontinental ballistic missiles, and precision-guided munitions to accurately acquire targets. GPS can also be installed into ground fighting vehicles for position monitoring by identifying other friendly forces positions and reducing the chance of fratricide. Also, pilots that eject from an aircraft during a mission can be located swiftly by using GPS receiver radios. GPS is also used to improve command, control,

and communication ability which enhances battlefield management. Assisting in frontline battle, GPS was also able to aid in logistics resupply. By attaining an accurate position on the drop zone, the transport aircraft is able to air drop the resupply item to the ground troops correctly without dropping them into the enemy's hands.

GPS and Fratricide Reduction

Although we have moved into modern warfare, the problem of fratricide is as old as warfare itself. The modern battlefield is more lethal than in the past because our ability to engage targets using modern technology exceeds our ability to accurately identify targets as friend or foe. The lethality and accuracy of modern weapons make it more deadly as compared to the past. Other factors like dust, smoke, rain, snow, and fog also downgrade the ability to identify the target and increase the chances of fratricide.

In modern battle, GPS can be used to assist in reducing fratricide in several ways. One of the better ways to identify friend or foe is to implement the GPS technology into the design of the machines, weapon systems, and individually worn equipment. For example, the Singapore Army's latest armor platform, the Bionix II Infantry Fighting Vehicle (IFV), has successfully implemented GPS technology. It integrated an array of platforms, including self-propelled artillery, unmanned aerial vehicles, attack helicopters and even ground troops by using the GPS based battlefield management system. Under this GPS network system, all the IFV crews are able to monitor each other's location and the position of the dismounted troops within the area of operations. The battalion was also able to synchronize an assault onto the same or different objective. GPS systems helped to facilitate the command and control of the battlefield which reduced the chance of fratricide in modern warfare.

During the Gulf War, the U.S. forces experienced a high fratricide rate. Of the overall casualty rate, more than 23 percent were killed and 15 percent were wounded by friendly fire. Immediately after the Gulf War, the U.S. Department of Defense placed a high priority on fratricide prevention and implemented anti-fratricide measures. One of the long term efforts is to focus on situational awareness and to integrate GPS with weapons and communications system. The results in OIF have shown that the fratricide rates have reduced since its introduction and implementation (Henneberry, 1995).

The identification of friend or foes location and position are always important for military operations. In today's operations, GPS provides absolute advantages in fratricide reduction. GPS provides accurate positioning information; high accuracy of GPS equipped precision weapons, improved self-location information and accurate target location which assist in reducing fratricide in modern warfare.

GPS is an important technology in modern warfare in reducing fratricide. However, the most important method in reducing fratricide is to enhance the situational awareness of the Soldiers, improve on the training method, executing proper coordination during battle, and ensuring proper management of the risk of fratricide. GPS is just a machine and the Soldiers are responsible for operating the machine.

GPS and Collateral Damage

The entire United States engaged in global operations for the security of our nation. This has caused our military forces to fight a totally different war than ever before. We have employed strategies of identifying and eliminating targets that were unthought-of in wars prior to the one we fight today. In the past after identifying targets, the Air Force usually dropped

bombs in a carpet type format to eliminate the threat. However, with GPS technology much of the collateral damage and fratricide associated with war is reduced.

Collateral Damage and Human Error

Even though the use of GPS does not entirely eliminate collateral damage mainly because of human error, destruction is still the common theme when it comes to conflict and fighting wars. The use of GPS minimizes the effects of collateral damage on the civilian populace because of GPS precision guided munitions and other measures put into place to minimize collateral damage.

As military forces struggle in both Afghanistan and Iraq to defeat insurgents on the ground, it can not totally control actions on the entire battlefield. The use of continued aerial bombardments has significantly enhanced operations and allowed forces to gain an edge on opposing forces through the use of this pinpoint accuracy. Many foreign officials may argue that pinpoint accuracy is not actually accurate, but rather that many civilians end up killed as a result of these bombing sorties. There are reports from the Afghan government, humanitarian aid organizations, and other human rights groups that say many civilians have died as a result of Western-style operations using military air support to help allied troops in trouble.

Military commanders on the ground look closely at the cause and effect of air operations, but cannot afford to totally change their strategies at this point in the war (Global Information Network, 2007). Air superiority offers the opportunity to cover a lot more ground than with the limited number of troops that operate on the ground daily in those regions.

Years after the U.S.-led invasion, coupled with troop shortages, and allied troop casualties, many commanders on the ground have become dependent on airpower to defeat insurgents with little to no collateral damage (Meller, 2007). However, the use of GPS should

minimize the effects of collateral damage on the civilian populace because of the use of GPS precision guided munitions. Guided missiles have a full range of capabilities due to the use of sensors, effectors, and data links that provide them with greater operational flexibility with the environments in which employed in the war against terror.

Missions can have a broad target spectrum, target changes, and sometimes mission aborts all within the same operation. For this purpose, the precision guidance and controlled effectors play a critical role in reducing collateral damage and providing the highest possible single-shot kill probability with as little collateral damage as possible. Precision-guided munitions also provide short reaction times between target detection and target destruction. It allows the capability of sufficient stand off protection for shooters of the munitions and troops on the ground (Scott, 2005).

Collateral Damage Reduction with Guided Munitions

The objective of today's armament is to maximize low weight and volume for easy air transportability with low costs to mission expenditures. All branches of the military use many platforms to deliver effects to the battlefield, but the most efficient method is through the means of GPS guided munitions. The use of the INS/GPS retrofit set HDAM, with which existing HARM missiles with cost effective upgrades can reach radar targets with GPS accuracy even if the radar has been turned off during missile flight. Some of the new Air-to-Air Missiles (AAMs) such as the IRIS-T and AIM-9X which provides short-range air-to-air guided missile capability are currently in production. Other developments like the AIM-120 AMFiAAM and the new European medium-range air-to-air guided missile METEOR have successfully passed their initial trial firings and seeker test flights (Hilburn, 2007).

Other important factors of GPS usage in combat that assist in minimizing collateral damage include a shorter reaction time between detonation and destruction of a target, not allowing the enemy to disrupt target engagement with jamming through the use of jam resistant GPS receivers, and pin-point targeting through the use of laser seeking guided missiles.

However, even with all the technological advances in precision-guided munitions, there is still one critical element that increases the risk of collateral damage in combat and that is human interaction. Regardless of how accurate munitions can be, the human element can affect the outcome by supplying incorrect data to the guided missile or laser targeting the wrong target which will ultimately cause collateral damage. These munitions and their capabilities are much similar to that of miniature on-board computers which supply the data that was loaded into it. Therefore, if inaccurate data is loaded, the outcome can cause more damage than initially intended for that target (Hilburn, 2007).

Although the use of GPS does not totally eliminate collateral damage because of human error, destruction is the common theme when it comes to conflict and fighting wars. However, the use of GPS should minimize the effects of collateral damage on the civilian populace for two main reasons. First, the use of GPS munitions helps to decrease the amount of possible damage through the use of precision guided systems. But most importantly, other measures like providing accurate information to these sophisticated systems prior to employment will ultimately help to minimize collateral damage.

It is safe to say that GPS in combat has enhanced the ability of combatant commanders to more accurately fight the close quarter battle on the battlefield without increasing fratricide or collateral damage to the civilian populist. There are many lessons from past battles that have shaped our vision of current operating strategies and the use of modern technology

gives the United States the operational superiority on any fighting front wherever and whenever our national security is at question.

Reducing Troop Exposure in Combat

The utilization of the GPS has enabled the United States Army to dramatically reduce the number of personnel exposed to enemy contact during combat operations. This essay will identify three areas that the GPS has directly impacted in the reduction of troop exposure to enemy contact: navigation, reconnaissance and surveillance, and missile and projectile guidance. The technological advances of the GPS are not only attributed to the drastic decrease in troop combat exposure but also to the reduction in Army combat casualties.

Navigation

There are two primary areas that the GPS has affected in the navigational arena: limited visibility maneuvering and coordinated unit movements. The basic navigational techniques of military forces began with orienteering by observing the sun, moon, and stars. Simplistic maps, compasses, and sextants improved upon celestial observation and lasted as a reliable means of navigation for centuries. However, in the last 40 years navigation has evolved into an exact science due to the GPS's creation from satellite technology, employment, and imagery. Navigational error has been reduced to inches due to the use of maps that are constructed from satellite imagery and global positioning devices that can be mounted in aircraft, ground vehicles, and carried by individual Soldiers (Aeronautics and Space Engineering Board, National Research Council, 1995).

The United States Army is world renowned for its ability to maneuver in any weather condition, day or night. The challenge of moving individually in limited visibility is an extremely

difficult task. Increasing the number of Soldiers and adding in combat vehicles exponentially multiplies the degree of difficulty. The GPS enables large formations to maneuver in day or night conditions regardless of the weather situation. Dust, wind, rain, and snow are some of the elements that would normally inhibit a unit's movement. However, the GPS can neutralize these elements and permit troops to travel as needed to fulfill mission requirements. This gives the Army a distinct advantage against our adversaries who are restricted against maneuvering in different types of limited visibility conditions. This directly relates to a reduction in the amount of time that our Soldiers are exposed to enemy surveillance and combat scenarios.

The second arena is coordinated unit movement. The majority of combat operations that result in direct fire are won by the element that executes precision movements and coordinated fires with speed and violence. Coordinated movement allows units to position themselves to set the appropriate conditions and to precisely maneuver while in the engagement area. The GPS enables any sized unit to execute coordinated movements regardless of weather conditions and time of day. Coordinated movement is interrelated with maneuvering in limited visibility and allows units to execute unrestricted movement through any terrain. Once again, this provides a distinct advantage in troop exposure to enemy direct or indirect fires which results in minimum injuries and casualties.

GPS technology has created the Movement Tracking System (MTS) and the Blue Force Tracker (BFT) to allow for maneuvering in limited visibility and executing coordinated movement. The MTS was developed for logistics personnel to track vehicles on the battlefield. It features messaging capabilities that allow for communication between vehicle crews and logistical trackers (Welsh, 2007). The BFT uses the GPS and computer technology to separate friend from foe on the battlefield to prevent friendly fire (Welsh, 2007). Additionally, it is

equipped with a distress button that enables the crew to call for assistance in emergency conditions. Logistical trackers can respond by dispatching a reactionary force to rescue the crew from ambush or injury (Scott, 2005). This system assists combat leaders in removing Soldiers from enemy exposure, contact, and potential capture.

Reconnaissance and Surveillance

The United States Army places great emphasis on utilizing reconnaissance to acquire enemy intelligence and identify potential target packages and surveillance to pinpoint targets and positively identify target packages. Reconnaissance is performed by aircraft, watercraft, ground vehicles, and dismounted personnel patrols. Non-human reconnaissance is performed by satellites, unmanned aerial aircraft, and through exploiting computer networks. Reconnaissance is an elemental tactic that assists in the development of the enemy intelligence picture and analysts rely heavily on GPS technology to build an intelligence package. Aerial photography that is digitally marked with exact positions from GPS triangulation can be fed at real-time and counter-tactics can be immediately employed against the aggressor. The combination of these reconnaissance techniques allow military planners to place troops in situations that expose them to less dangerous scenarios. It allows troops to ambush the enemy instead of being attacked, to disrupt potential attacks before they develop, and to strike deep targets that can break the enemy's internal structure.

Surveillance allows the Army to monitor the actions and behaviors of people and their processes. Surveillance can be performed as an overt or covert operation depending on mission requirements. The technique of surveillance has evolved with the automation of computers and systems networks allowing for the extensive storing of activity records. The greatest impact of computer-enabled surveillance has been the large number of organizations that are involved in

surveillance operations (Wikipedia, 2007). The sharing and processing of information allows analysts to supply military planners with specific intelligence that shapes the employment and utilization of troops. Consequently, troops can avoid potentially dangerous engagements and exposure to enemy resistance.

Missile and Projectile Guidance

The United States military has developed various weapons systems that utilize the GPS to track potential ground and air targets before they are marked as hostile. These weapons systems pass GPS coordinates of targets to precision-guided munitions to allow them to strike the target with pinpoint accuracy. This accuracy is provided by portable wide-area differential GPS stations that are placed between 1,000 and 1,200 miles apart (Fulghum, 1995). This can eliminate error and improve the accuracy of satellite-guided weapons to within 25 feet of the intended target. Precision-guided munitions are purposely designed to maximize damage to the target while reducing the potential for civilian casualties, collateral damage to infrastructures and eliminating the need for ground troops to destroy the target by more conventional means.

There are two munitions of choice for the military that deliver maximum lethality with unequaled precision provided by the GPS. They are the Joint Direct Attack Munition (JDAM) and the Joint Stand-Off Weapon (JSOW). With accurate targeting information they are substantially more likely to achieve a catastrophic strike without regard to the weather conditions than any other form of precision-guided munitions. In addition to the GPS guidance element, both are redundantly outfitted with laser-guidance packages to compensate for a GPS failure. However, with both systems simultaneously in operation the JDAM and JSOW have the best overall accuracy of any other precision-guided systems in production with a range of 15 nautical

miles from the release point. Their accuracy and versatility ensure mission flexibility and employment against moving and fixed targets of opportunity (Wikipedia, 2007).

The JDAM is the more versatile of the two systems. It can be launched from very-low to very-high altitudes, in a dive, or in straight-and-level flight. Once released, the JDAM can autonomously navigate to the designated target coordinates. Coordinates can be inputted prior to take-off, altered manually prior to release, or edited from onboard targeting equipment. Every JDAM and JSOW that is employed to destroy a designated target eliminates the need for mounted and dismounted troops to be exposed to enemy contact. Likewise, continued air dominance will permit the United States military to employ GPS precision-guided munitions to reduce the number of troops that are necessary to be exposed to enemy direct fire scenarios.

The development of the GPS has had a direct impact on today's modern battlefield. Precise navigation in limited visibility conditions and coordinated troop movements has been greatly enhanced by the GPS devices available to air and ground personnel. The military intelligence and behavior patterns that are gathered and are crucial in building credible target packages originate from reconnaissance and surveillance tactics that are created by GPS technology. The delivery of precision-guided JDAMs and JSOWs with deadly accuracy in any weather condition is the result of GPS missile and projectile technology. The GPS's contribution is immeasurable in terms of reducing troop exposure to enemy contact and in the number of American lives that have been spared from direct and indirect fire engagements with enemy aggressors and potential networks of terrorists.

Future Global Positioning Systems Technologies

The future technology and employment of GPS in combat will produce more precise weapons, better tracking capabilities, and less troop exposure that will reduce fratricide,

collateral damage, and the amount of time Soldiers that are exposed to danger during combat operations. These technological advances and employment practices will forever change the face of combat operations.

Munitions

Just as the first guided munitions revolutionized the conduct of strategic bombing, the future technologies in missiles and bombs prove to be just as revolutionary. The focus of missiles and bombs is no longer just the ability to hit a target from a faraway distance, but to eliminate the need for a laser to pinpoint the location of the missile or the bomb. The focus has turned to using a GPS seeker instead of laser. The seeker guides the munitions to its target based on a set of pre-programmed coordinates. The desired effect of the GPS seeker is to eliminate the need of a laser pinpointing the target and to allow the delivery platform a greater stand-off distance (Arora, 2006).

The advancement of GPS technology has taken guided munitions from bombs and missiles into the arena of indirect fire artillery munitions. GPS receivers have gotten smaller, and with the smaller components come the ability to use them in new ways. Couple the GPS receiver with a small laser, and now the ability to deliver precision indirect fired munitions is a reality. The precision of these indirect fire munitions is currently being tested at 50m and is estimated to be as low as 30m when actually fielded (Unknown, 2006). The ability to deliver guided artillery munitions on the battlefield allows the commander on the ground to use direct fire in situations where it was previously deemed too risky.

The technological advancements in guided munitions has provided the military an effective means to deliver ordance with extreme precision. This precision reduces the amount of collateral damage because a single target can be destroyed without taking out an entire city

block. This precision allows commanders to deliver ordnance closer to friendly troops without the worry of human error. The new technology allows the method of delivery to remain further out of harms way and reduces the chance that military troops may be exposed to hostilities.

Tracking Systems

GPS technology has not only helped the war fighter deliver more precise munitions, but it has greatly increased the ability to track Soldiers on the battlefield. Currently, the United States military is tracking vehicles on the battlefield with the BFT, FBCB2, and the MTS systems. This technology tracks the crew of a platform, but not the individual. Again, the technology that has reduced the size of the GPS receiver will play a significant role on how commanders track the individual Soldier. Though the military has not specifically mentioned how it plans to track the individual on the battlefield, there are two technologies that would definitely prove feasible and plausible.

GPS microchips are one approach to tracking individual Soldiers. A small microchip placed under the skin would allow Soldiers to populate a commander's situational awareness screen. This current technology is being utilized by law enforcement agencies as a means for tracking criminals (Research, 2006). It is a relatively new technology and the data regarding the ability to accurately track an individual is not available, but the technology exists and is only a matter of time before it is able to be effectively employed.

GPS tracking tags provide the same ability as the GPS microchips. They are not as small nor are they as stealthy as the microchips. The tracking tags or collars are similar to what is currently being used to track animals in the wild, and have had great success. The tags could be donned by the Soldier prior to each mission, but could also be removed if captured or during the normal routines of combat operations. One means being developed to visibly remove the

tracking tag is to imbed the tracking system into the clothing or equipment of the Soldier (Eramo, 2005). The GPS tracking system would remain with the Soldier as long as he/she had their clothing or equipment.

Regardless of the means the military chooses to track the individual Soldier, the end result will be a better situational awareness on the battlefield. This awareness will allow commanders to see intricate details never seen before that will prevent fratricide and the loss of a fellow Soldier on the battlefield.

Aerial Systems

The Unmanned Aerial Vehicle (UAV) has proven to be the future of intelligence gathering and precision strike. UAVs are currently providing commanders with real time video surveillance of routes, targets, and key terrain. Additionally, these UAVs are being utilized as platforms for precision munitions. As the technology to decrease the size of the GPS receiver continues, UAVs will continue to become smaller themselves, and with the decreased of avionics they will be more capable of carrying larger payloads of munitions or fuel (Syntronics, 2006). These advances will drastically increase the amount of station time a UAV has and diminish the gaps created by getting a replacement UAV on station. Additionally, a smaller UAV provides the commander a stealthier means of observing the critical targets.

GPS technology has also increased the ability to deliver supplies and equipment to ground forces with precision. Gone will be the days of hoping that air dropped supplies reach the ground unit. These guided parachutes utilize the same technology as guided munitions and are benefitting from the decreased size of the GPS receiver as well as independent guidance units (Defense Update, 2006).

The future technologies of GPS will drastically reduce the amount of troops required to conduct many combat operations. The UAV and guided aerial delivery systems will change the way the military conducts surveillance, precision strike, and re-supply operations.

The advancements in GPS technology will forever change the way the United States conducts combat operations. This new and enhanced technology provides us with more precise munitions that drastically reduce collateral damage and the potential for fratricide. We will further reduce the potential for fratricide by being able to track the individual Soldier and coordinate our fires with more precision. GPS technology touches every aspect of operations and the affects will be felt worldwide.

The Global Positioning System's Weaknesses in Combat

The exploitation of GPS signals allows the adversary to gain a battlefield edge, and ultimately outweighs the effectiveness of its use during war. The adversary is becoming quite successful in using a jamming signal to render GPS ineffective. When this signal exploitation occurs it has an enormous impact on U.S. forces operations. It impacts complex equipment like GPS guided munitions, while also impacting simple radio equipment used on a daily basis by Soldiers.

Jamming Defined

When GPS was developed decades ago, it was designed to operate in an electronic environment free from attack. The threat of exploiting the signal simply didn’t exist. However, times changed during technological advances and Electronic Warfare (EW) became a significant part of the battlefield from the late 1980s and forward. Jamming is a component of EW. GPS receivers rely on an accurately transmitted radio frequency signal from a satellite. The signal literally travels thousands of miles through space before it reaches a GPS receiver. This satellite

radio signal can be distorted either intentionally or unintentionally before it reaches the intended receiver. When the signal is distorted by another transmitted radio frequency signal it is said to be jammed. It is significant to note that the armed forces of the United States became more reliant on GPS technology and began to use GPS in a variety of ways. GPS guided munitions, radios with GPS capabilities, blue forces trackers, and hand held GPS receivers all have become commonly used on today's battlefield. These pieces of equipment all require that the GPS signal received from orbiting satellites is accurate and timely. If the signal is distorted in anyway, the grid coordinate calculated by the GPS receiver will not be as accurate as it could be, and depending on the strength of the distortion, the grid coordinate error could be as much as hundreds of meters to a few kilometers. Simply put, when any type of distortion is caused to a GPS receiver, the receiver is confused and the resulting error can be very dramatic (Erwin, 2000). All EW experts agree that jamming a GPS satellite signal is a simple task and only requires a bit of modest equipment to build a successful jamming device (Battle Against Terrorists, 2001). This is particularly important in OIF. The adversary has proven its worth by using low cost resources that yield big results in disrupting coalition efforts. Building an inexpensive jamming device capable of jamming signals across a radius of several kilometers can cost less than 500 dollars, and can be built by following web based instructions (Battle Against Terrorists, 2001).

Types of Jamming Devices

Any transmitter that emits a signal can be used as a jamming device. Two radios that are keyed at the same time are not able to broadcast with clarity because they are actually jamming one another's radios. This is a simple example of jamming. Many types of radio frequency jamming devices exist in both the commercial and military worlds. These devices are made to be

portable and relatively lightweight, and can be left to jam remotely without having the need for the presence of an individual to operate the system. Overseas manufacturers are designing jamming devices to specifically counter United States assets. One example is the Moscow produced jammer specifically advertised in a Paris, France air show to combat the effectiveness of the Tomahawk cruise missiles. The jammer weighs less than seven pounds, and emits a very low signal which makes it extremely difficult to detect and locate. The manufacturers claim that it's effective in jamming signals over a radius of hundreds of kilometers (Herskovitz, 2000). A less costly alternative can be made with easily obtainable parts for less than 500 dollars. This jammer is a ridiculous three inches in diameter and is referred to as a hockey puck jammer. It transmits using only one watt of power, making it nearly impossible to detect. It was both tested and effective in jamming GPS signals (Herskovitz, 2000). Jammers can be classified into two categories: continuous wave and broadband. Continuous wave jammers operate by sending a constant signal on a specific frequency. These jammers are relatively easy to detect and counter. The broadband jammers are more effective, however. This jammer transmits a signal that bounces around randomly and is difficult to predict. Defending against the broadband jammer is a very difficult task (Erwin, 2000). The availability of information on how to build a jammer, combined with the already manufactured versions, make the GPS signal easily exploitable by the adversary.

Jamming Effects

The effects of jamming the GPS signals greatly degrade the armed forces of the United States. Soldiers rely on not only military issued GPS systems such as the Precision Lightweight GPS Receiver (PLGR), but also commercially purchased systems produced by such companies as Garmin. It is proven in tests in and around Baghdad, Iraq that the PLGR and commercial

systems are very prone to jamming (Grantham, 2005). The negative impact of this jamming can be tremendous. Soldiers constantly use GPS receivers to determine exact grid coordinates to conduct raids on suspected terrorist locations in OIF operations. The consequences of conducting a raid on the wrong house in a particular village can be devastating to the overall goal of coalition forces. Innocent lives can be lost simply because of a grid coordinate error as small as 20 meters given by a jammed GPS receiver. Entire villages suddenly turn from supporting coalition forces, to condemning their actions. Extreme circumstances lead the villagers to stop cooperation with U.S. forces and side on the cause of the insurgents.

United States Air Force GPS guided missiles have both lived and died by their successes and failures in OIF. When these missiles are accurate, they provide an incredible advantage to the user; however, when they're inaccurate they most often times result in innocent lives again being lost. The ability to jam this GPS signal negatively impacts effective strategic targeting by U.S. forces, and creates a disadvantage when trying to win over the local Iraqi population. When homes are destroyed and innocent lives are lost, the world's media is quick to spread the story and share in the burden of the suffering. Naturally, public opinion is swayed and weapons technologies are ultimately questioned, at a minimum.

Blue forces tracker is another system employed by the U.S. forces that can be degraded by a jammer. Conducting simple operations such as vehicle linkups can easily turn into a fratricide incident because of jammed devices and faulty grid coordinates.

The adversary can gain a clear advantage by mastering the use of jammers on today's battlefield. Much of the equipment used by U.S. forces depends on the accuracy of the GPS signal, and this over reliance on GPS systems by U.S. forces is proving to be a weakness. If the adversary gains this advantage in the EW realm, the impact might be devastating for our forces.

The separation of the fight provided by GPS guided missiles will be taken away. The ability to track friendly forces locations and activities through blue forces tracker will be gone. The individual Soldier having the quick ability to gain an individual position will be no more. One small signal emitting one watt of power might have a detrimental impact on today's battlefield, and future operations.

Conclusion

GPS use in combat has given the United States armed forces a clear advantage in present conflicts in comparison to those of the past. The future will only be brighter as the GPS use is refined and protected against exploitation. Technological advances continue to grow at a rapid pace, and GPS use positively attaches itself to these advances. GPS has made a positive mark in today's battles, and a safeguarded GPS signal will continue to give U.S. forces a clear advantage in the areas of fratricide, collateral damage, troop exposure, and future GPS integrated technologies.

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